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Science has improved our lives in many ways. It has lightened the load of tedious tasks and multiplied our physical powers, thereby contributing to a greater flowering of our creative capacities. But it has led also to a sense of malaise among those who seek a better understanding of how we human beings fit into nature, and how we should therefore conduct our lives. As Nobel Laureate Steve Weinberg said recently: "The more the universe seems comprehensible, the more it seems pointless."

The difficulty in extracting from science any insight into the meaning of our lives stems in part from the fact that the physical sciences have, until recently, focused primarily on describing the behavior of matter. But the important and exciting news is that the intensive study of the properties of matter has revealed fundamental flaws in our earlier understanding of the basic nature of the physical universe and our role in it, and this deeper understanding impacts strongly on human concerns.

My intention here is to introduce you to the vistas opened up by our new deeper understanding of the nature of the physical universe. These advances lead me to believe that, in the end, the greatest gift of science to humanity will be not its material benefits, but rather its impact on our values, generated by what it reveals about human beings and our connection to the rest of nature.

It is often claimed that science has no connection to values. To counter that idea I shall begin by sketching out a bit of human intellectual history.

I divide this history into five periods: traditional, modern, transitional, post-modern, and contemporary.

During the "traditional" era our understanding of ourselves and our relation to nature was based on "ancient traditions" handed down from generation to generation: "Traditions" were the chief source of wisdom about our connection to nature.

The "modern" era began in the seventeeth century with the rise of what is called "modern science". That approach was based on the ideas of Bacon, Descartes, Galileo and Newton, and it provided a new source of knowledge that came to be regarded by many thinkers as more reliable than tradition.

The basic idea of modern science was "materialism". This is the idea that the physical world is composed basically of tiny bits of matter interacting with each other according to "laws of nature" that—given the state of the universe at early times—completely determined the course of physical events for all time.

According to these laws, as they existed at the end of the nineteenth century, a person's conscious thoughts and efforts make no difference at all in what his body does: his every action is going to be what it ordained to be from the beginning of time by local contact interactions between tiny bits of matter.

This materialist conception of reality began to crumble at the beginning of the twentieth century with Max Planck's discovery of the quantum of action. Planck announced to his son that he had, on that day, made a discovery as important as Newton's. That assessment was certainly correct: the ramifications of Planck's discovery were soon to cause Newton's materialist conception of physical reality to come crashing down. Planck's discovery marks the beginning of the "transitional" period.

A second important development soon followed: In 1905 Einstein announced his special theory of relativity. It denied the validity our intuitive idea of the instant of time "now", and promulgated the thesis that even the most basic quantities of physics, such as the length of steel rod, and the temporal order of two events, had no objective "true values", but were well defined only "relative" to some observer's point of view.

Planck's discovery led by the mid twenties to a complete break-down, at the fundamental level, of the material conception of nature. A new basic physical theory was developed, principally by Werner Heisenberg, Niels Bohr, Wolfgang Pauli, and Max Born, and it brought "the observer" explicitly into physics. The earlier idea of describing reality completely in terms of tiny bits of matter was abandoned, and science was taken to be simply a human endeavour to understand the structure of human experience, rather than nature herself. This successor to classical physical theory is called "Copenhagen quantum theory".

The turning away by science itself from the tenets of the objective materialist philosophy lent support to Post-Modernism. That view, which emerged during the second half of the twentieth century, promulgated, in essence, the idea that all "truths" were relative to one's point of view, and were mere artefacts of some particular social group's struggle for power over competing groups. Thus each social movement was entitled to its own "truth", which was viewed simply as a socially created pawn in the power game.

The connection of Post-Modern thought to science is that both Copenhagen Quantum Theory and Relativity Theory had retreated from the idea of observer-independent objective truth: science in the first quarter of the twentieth century had not only eliminated materialism as a possible foundation for objective truth, but had discredited the very idea of objective truth in science. Yet if the community of scientists have renounced the idea of objective truth in favor of the pragmatic idea that "what is true for us is what works for us," then every group becomes licensed to do the same, and the hope evaporates that science might provide objective criteria for resolving contentious social issues.

This philosophical shift has had profound social ramifications. But the physicists who initiated this mischief were generally too interested in practical developments in their own field to get involved in these philosophical issues. Thus they failed to broadcast an important fact; already by mid-century, a development in physics had occurred that provides an effective antidote to both the 'materialism' of the modern era, and the 'relativism' and 'social constructionism' of the post-modern period. John von Neumann developed, during the early thirties, a form of quantum theory that brought the physical and mental aspects of nature together as two aspects of a rationally coherent whole. This theory was elevated by the work of Tomonaga and Schwinger, during the forties, to a form compatible with the physical requirements of the Theory of Relativity.

Von Neumann's theory, unlike the transitional ones, succeeded in integrating into one coherent idea of reality the empirical data of subjective experience with the basic mathematical structures of theoretical physics. Von Neumann's formulation of quantum theory yielded a conception of a psycho-physical reality embodying observer-independent objective truths.

Let me explain how von Neumann accomplished these things.

The earlier Copenhagen approach applied the principles of quantum theory only to relatively small systems, and used classical concepts to describe the rest of nature. This procedure of treating different parts of the physical world in logically incompatible ways worked beautifully at the practical level, but introduced severe logical difficulties. These logical difficulties were evaded in Copenhagen quantum theory by simply renouncing the search for an understanding of objective reality: "if it works, that's good enough."

But von Neumann demanded logical coherence, and this meant treating the entire physical universe, including our bodies and brains, quantum mechanically, and connecting a person's conscious thoughts to activities in his brain in accordance with laws provided by the theory itself.

This new integral conception of the human person departs radically from the earlier scientific picture of man in three important ways:

1. It is based on A NEW CONCEPTION OF MATTER that differs profoundly from the old one, which is provably false.

2. It automatically produces a bona fide, rather than illusory, FREE WILL.

3. It allows for THE CO-EVOLUTION OF OUR MIND AND BRAIN from a primitive beginning to its present complex form.

These three changes add up to a rationally coherent conception of the human person that differs profoundly from the caricature that arose from materialism.

To appreciate these changes one needs, first of all, to understand the new idea of matter, where by "matter" I mean the "stuff" out of which the physical universe is made.

The quantum conception of this 'stuff' is radically different from the idea of matter postulated by Isaac Newton and his successors. The properties of "quantum matter" lie "mid-way" between those of the classical idea of matter and the intuitive idea of mind: the "stuff" of the physical universe has both matter-like and mind-like characteristics.

But how can anything lie "midway" between mind and classically conceived matter? The two ideas are so totally different that it seems that nothing could share properties of both. Indeed, many earlier thinkers had surmised that nature ought to be built out of some intermediate kind of stuff, but the way to achieve this was finally grasped by quantum physicists only as a consequence of their intense and unrelenting efforts to comprehend the baffling character of the empirical data and of the mathematical structure that accurately described many of its features.

This melding of mind and matter arises as follows: the quantum state of a system is essentially a "cloud" of possible states of the kind described by the classical physics of the nineteenth century. Each droplet in the cloud is like a possible classical system. Thus the individual droplets bring certain classical-physics properties into the quantum system. However, the cloud acts as a unit, and the overall shape of the cloud constitutes an "informational structure".

To understand this idea of "information", consider a system consisting of a single particle confined to a box, and suppose the question is posed "Is the particle in the left-hand half of the box?" and that Nature then delivers the answer 'No'.

That answer constitutes one bit of information, and this information is incorporated into the state of the system by resetting the shape of the cloud. Thus if Nature's answer is No, then the part of the cloud that occupies the left-hand half of the box is taken away. This resetting incorporates into the quantum state of the system the new bit of information.

This simple example captures the essence of quantum dynamics: a sequence of Yes-No questions is posed, and nature delivers an answer, Yes or No, to each such question. Each answer constitutes one bit of information, which is incorporated into the quantum state of the system by resetting the shape of the cloud.

This description of quantum dynamics focuses attention on a peculiar but essential aspect of quantum dynamics: the necessity of a sequence of Yes-No questions. Without these questions nothing actually happens: the universe, and every subsystem of the universe, just keeps evolving into an ever-expanding clouds of possibilities, with no actuality.

The key point here is that the mathematics of quantum physics makes the dynamics like a game of twenty questions. To get anything factual out of this mathematical structure a sequence of questions that require Yes or No answers must be posed. Nature delivers answers to these question, and those answers are subject to statistical laws: the relative probabilities of Yes and No are fixed by the mathematical rules. However, there is nothing in the mathematics that fixes what these questions are! That is the key point!

This is where the participant/observers enter into quantum theory. According to both the original Copenhagen formulation and von Neumann's reformulation the questions are posed by the participant/observers.

von Neumann placed the entire physical universe, including the bodies and brains of these human observers, in the system described by the quantum mathematics. This resolved the difficulties arising from the ad hoc separation of the one physical universe into two differently described parts that obeyed different laws. But it did not alter the essential feature that the known laws of physics, even with the entire physical universe included, simply do not fix the "questions posed by the participant/observers". This means that the known laws of physics are not complete. The dynamical gap introduces into the basic dynamics an essential element of freedom that is not under the control of the known laws, but that appears to be under the jurisdiction of what von Neumann called the "abstract ego" of the participant/observer. This 'abstract ego' is whatever is left of the participant/observer after his body and brain have been shifted. into the mathematically described physical universe.

What is a typical question?

In the context of a quantum treatment of a human person's mind-brain the question is always of the form:

Will the experience E associated with the neural correlate of consciousness N(E) appear now in that human person's stream of consciousness. Here von Neumann, like contemporary neuroscience, and psycho-physics, ackowledges the fact that our scientific description of the mind-brain has two kinds of data that are described in different languages. One of these languages is the language of physics, which pertains to locations, shapes, and motions in space of entities regarded as built in some sense out of atomic particles and molecules, and the other is the language of psychology, which is used to describe the feelings and ideas of the participant/observer. The aspects described in these two different ways are related by what called "the neural correlate N(E) of an experience E".

This neural correlate is the set of activities in the physically described brain of a participant/observer that is assumed to be occurring in conjunction with his occurring experience E: N(E) is the brain counterpart of the experience E.

Two kinds of experiencs are particularly important. One is the experience of ‘coming to know’ something, such as the color, red or not red, of yonder traffic light, and the other is the ‘feeling of effort” to attend to, and hold in place, some idea that would, without that effort, flit away. In the first example the question would be ”Is the next experience in my stream of consciousness going to be seeing the red light, and experiencing it in the particular way W?” In the second example the question will be ”Shall I continue to attend to action A?”, where A might be thinking about some particular idea, or pursuing some particular course of physical activity.

In general, the cloud of possible classical brain states will be some amorphous cloud of possibilities that is diffusing, or spreading out, due to the indefiniteness engendered by the Heisenberg uncertainty principle. AFTER some particular possible experience E is selected, THEN this cloud of possibilities can be separated into two well defined parts, the part that is compatible with experience E and the part that is not. The next step in the dynamical process is Nature’s delivery of the answer, Yes or No. There is a statistical constraint on that answer. But the KNOWN laws of physics do not specify which possible experience E will be picked out by the question put to Nature.

If Nature’s answer to the actually posed question is Yes, then the cloud of possibiliies will reset in a way that eliminates all classically described components that are incompatible with experience E. If the answer is No, then the resetting will eliminate all classically describable components that do not contain a possible neural correlate of E. This resetting of the quantum state to a form that is compatible with the new human experience is the key feature of Copenhagen quantum theory, and it is retained in von Neumann quantum theory. The significant nontrivial fact is that mathematics of quantum theory naturally calls for this question and answer scenario.

The resetting of the quantum state generates the mysterious ”action at a distance” that Einstein found so objectionable. This action at a distance cannot be avoided if one demands a rationally coherent idea of a reality that accords with the predictions of quantum theory. On the other hand, this action is a subtle sort of information transfer that does not actually violate any of the physical requirements of the theory of relativity.

Copenhagen quantum theory copes with this embarrassing "quantum non-locality" by separating the physical universe into 'observed' and 'observer', and renouncing the quest for an understanding of reality itself. von Neumann's approach is simply to treat the whole physical universe in the way demanded by the quantum mathematics, and not be intimidated by the implied need for instantaneous tranfers of information that do not violate the physical requirements of the theory of relativity.

In a classical treatment there is no "free choice" that can—for fixed intitial conditions—divert the physical activities into one path or another.

But quantum theory allows such "free choices". These free choices do not involve any biasing or alteration of any known quantum law, including the statistical rules. Yet they can—for fixed initial conditions— channel physical activities into one path or another.

These free choices are the choices of which question to pose and when to pose it. Proving that these free choices can direct physical activities into one path or another is a straightforward technical task which, however, I shall describe not describe here, except to say, for the benefit of physicists, that it is a Quantum Zeno Effect.

Quantum theory thus introduces an efficacious element of "free choice" into mind-brain dynamics. One can no longer validly assert that our actions are governed by impersonal, local, mechanical laws, and that a person's every action is predetermined already at the big bang by the known local, mechanical laws. There may be absolute predetermination, but if there is then it certainly is not via the currently known physical laws, which do, nevertheless, account for all the valid predictions of both classical and quantum physics.

So far I have focused on the quantum dynamics of the human mind-brain. One reason for doing this is that quantum theory was originally formulated in terms of the experiences of human beings: "pigs don't do science." Von Neumann's immediate objective was to reproduce in principle the predictions of the earlier Copenhagen quantum theory. He thererfore needed to include in his dynamics the human experiences that were the basis of the earlier formulation.

Another reason for starting with human beings that it is only through our human experiences that we know that streams of consciousness exist. The data contained human streams of conscious events are directly accessible to human beings, and are, in the end, the sole data of all science, including the science of the mind-brain connection.

In spite of the special role of human beings in both Copenhagen and von Neumann quantum theory, I regard it as axiomatic that our human mind and brains co-evolved from simpler structures. Continuity then demands that each of these simpler "mind-brain" structures must also have the capacity to reset the evolving cloud of possibilities that constitutes its quantum state. This capability gives to the evolving mind-brain the efficacy it needs in evolutionary psychology and evolutionary biology: a non-efficacious mind has no physical consequences, hence no survival value, and hence no capacity to evolve by natural selection.

Copenhagen quantum theory and von Neumann quantum theory both enlarge the basic ontology, by bringing in the conscious experiences of the participant/observer as irreducible realities. A pain is a pain is a pain: a pain is not "really" something else. Classical physical theory also can accomodate experiences as irreducible realities, but in the classical case if experiences are not built out of matter then they must be epiphenomenal.

That solution—epiphenomenal/nonefficacious consciousness—is a 'solution' that most contemporary thinkers disfavor. But in the quantum case the experiential realities can affect physical properties without being physical.

Von Neumann's argument involved shifting the boundary between 'observed' and 'observing' systems. At the final stage of the analysis all parts of nature that are classically conceived to be built out of atomic particles (and the EM and Gravitational fields) are included in the quantum physical universe. But the "agents" that stands outside physical universe and are responsible for the "free choices" are not included. This experiential aspect is called by von Neumann the "abstract ego".

This line of argument suggests that the selecting agent, or process, stand outside the physical universe described by the quantum mathematics.

That may indeed be the case. But all that is really known is that the currently known laws are incomplete: some way of fixing which questions are posed, and when they or posed, is needed to complete the dynamics. However, as stressed at the beginning of this talk, the quantum conception of 'matter' already has psychological aspects. Hence it is possible that a deeper understanding would allow a person's thoughts to be seen as aspects of his quantum-mechanically described brain.

I have adhered, so far, to the restricted program of just following through on von Neumann's approach without adding any speculative ideas. The question of exactly what determines which questions are posed by the participant/observers is not answered within that program, which does, nevertheless, provide a rationally coherent conception of the evolving universe that accounts for all the validated predictions of classical and quantum physics, as well as the effects upon brain activities of effortfully focused attention [1]. The fact that all this can be achieved without specifying whether our minds lie inside or outside the physical universe it means that science, rationally pursued, is still mute on some very basic questions about the nature of man. But one thing is certain: we are not necessarily the mechanical robots that classical physics proclaimed us to be.

SUMMARY

A malaise has been created by the seeming pointlessness of life as seen through the eyes of science. For centuries science has been proclaiming that each human person is naught but a mechanical automaton whose every act was pre-ordained before he was born. But in the early twentieth century basic science, in an about face, renounced the search for objective truth and settled for practical success. Thus the attempt to base our lives on science and reason led, seemingly, into the abyss of moral relativism. However, that transitional science systematically avoided, as too difficult, or beyond its scope, the basic question at issue, which is the nature of the human person and his connection to the rest creation. Contemporary science reveals a far richer conception of what we are than earlier science and philosophy had imagined. We can now understand how man is endowed with efficacious free will, and, far from being an isolated glob of proto-plasm, is nonlocally entangled with the rest of nature in a way that completely transcends the materialistic concepts of Newtonian physics. Although the full implications of this deeper understanding of the human person has yet to be made fully clear, we have at least been rescued

from the demoralizing notion that science shows us to be, basically, nothing but a conglomeration of tiny particles careening mindlessly through space.

[1] Quantum theory and the role of mind in nature. http://www-physics.lbl.gov/ stapp/stappfiles.html

OUTLINE

Part I: The Physics of Consciousness (ala Bohr/von Neumann).

MIND

Mind plays a basic role in orthodox (Bohr/vonNeumann) QT: The theory is about the mathematical structure of connections between human actions and experiences.

MATTER

The stuff of the physical universe is partly mind like: the physical universe is a CLOUD of possible classical universes, and the shape of this cloud represents information.

FREEDOM

There are TWO KINDS of "free" choices: NATURE'S "free" choices are subject to statistical laws. HUMAN "free" choices are subject to no KNOWN laws.

WILL

Human "free" choices are EFFICACIOUS: they can strongly influence brain activity.

NONLOCALITY

Human "free" choices have "instantaneous" effects far away: we are "nonlocally entangled" with rest of nature.

Part II: Moral Impact.

Science has shown the materialist conception of nature to be false.
By validating free will it has rescued "Personal responsibility".
It has also resuscitated "Objective truth".
And it has made our minds into efficacious aspects of the highly nonlocal process that creates the growing informational structure that is the physical universe.